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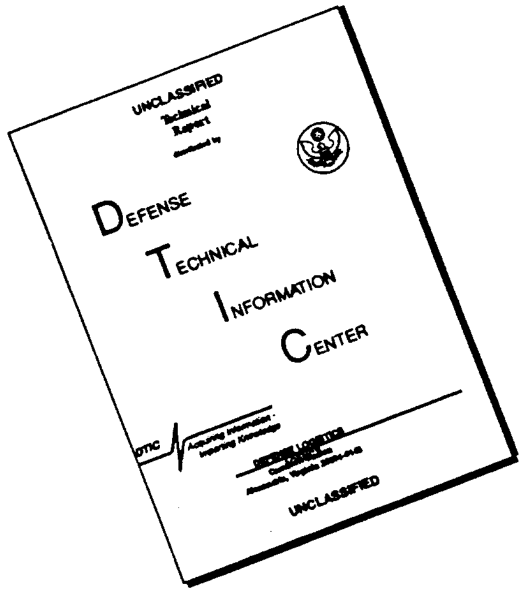

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U.S. ARMY - BAYLOR UNIVERSITY

GRADUATE PROGRAM IN HEALTH CARE ADMINISTRATION

WOMACK ARMY MEDICAL CENTER'S PRE-ADMISSION UNIT

A GRADUATE MANAGEMENT PROJECT

SUBMITTED TO

LTC MICHAEL H. KENNEDY

U.S. ARMY - BAYLOR UNIVERSITY

GRADUATE PROGRAM IN HEALTH CARE ADMINISTRATION

BY

CAPTAIN THOMAS H. BERRY

FORT BRAGG, NORTH CAROLINA

NOVEMBER 1995

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CHAPTER 1

INTRODUCTION

The delivery of health care in the United States has changed significantly since the introduction of Diagnosis Related Groups (DRG) by the federal government in 1983. Prior to that, health care was primarily hospital-based and third party reimbursements for inpatient services were generally cost-based. With the introduction of DRGs, reimbursement rates for most inpatient services became predetermined which caused hospitals to become more cost efficient, and it shifted the delivery mode for health care to outpatient services. This concept also shifted the business philosophy of hospitals, since they were no longer reimbursed on a cost-basis, to encourage decreased length of stays thereby increasing profits (Wasted Health Care Dollars, 1992).

The Department of Defense did not shift its budgeting philosophy until the early 1990s. Before then, an increase in work units resulted in increased funding. In 1994, the Assistant Secretary of Defense for Health Affairs published a set of policy guidelines for implementing managed care reforms in the military health services system. One of the key concepts was to allocate financial resources based on a capitation-based methodology. Consequently, there is no longer any financial incentive to increase the number of services or provide any more costly care than is medically necessary. Capitation budgeting requires hospital commanders and their staff to continuously assess the

efficiency of the health care services provided, because theoretically cost-savings are held internally and cost-overruns require additional funding assistance from the organization's parent headquarters. This headquarters for all U.S. Army health care organizations is the U.S. Army Medical Command located at Fort Sam Houston, Texas (OSD-HA 1994).

At Womack Army Medical Center (Womack), outpatient visits have increased by fourteen percent from calendar year 1990 to calendar year 1994. Simultaneously, inpatient bed days and average length of stays have decreased by twenty-one and twenty-five percent, respectively (King 1990/1994). Given this trend toward the outpatient delivery of health care services, and the added incentive to constantly assess the internal efficiencies of an organization in a capitated environment, Womack must continually improve the processes in place in order to provide quality health care that is affordable, accessible, and patient focused.

Conditions Which Prompted the Study

The Pre-Admission Unit (PAU) at Womack exists for reasons similar to those identified in the literature during the mid-1980s. Some of these reasons are to increase the patient's satisfaction and familiarity with the surgical process, provide the most cost effective medical care without sacrificing quality, ensure an expeditious admission process due to prospective testing and interviewing methods, and detect any health

abnormalities which could lead to cancellations or unnecessary bed days (Sabin 1985).

In October 1994, the new officer in charge (OIC) of the PAU was already familiar with the way patients were inconvenienced during the pre-admission process because he saw them waiting in hallways for many hours on a daily basis. LTC Salvatore A. Ciresi, the new OIC, was previously responsible for overseeing the Anesthesia Nursing Section, and had just assumed the task of overseeing the Operating Room, the Intensive Care Unit, the Recovery Room, and the Ambulatory Surgery Unit (ASU). These new responsibilities required LTC Ciresi to switch from the management of functional tasks to one that involved a multifaceted approach with multifunctional specialties. His biggest challenge was to reorganize a pre-admission process that improved patient satisfaction, decreased long waiting lines, and continually improved the quality of care.

When LTC Ciresi assumed the responsibility of the ASU he was beginning to understand why many of the inefficiencies he was familiar with existed within the pre-admission process. Each day at 1:00 p.m. twenty patients presented themselves with the same scheduled appointment time for pre-admission processing. Logically, there should be one individual overseeing all aspects of the pre-admission process since it involves provider's from the Department of Surgery, the Department of Nursing, the Laboratory Service, Radiology, Cardiology, and the Patient Administration Division. However, until LTC Ciresi was placed in

charge, nobody was directly responsible for the pre-admission process which often required patients to wait several hours in crowded waiting rooms and hallways.

In November 1994, I decided to access Womack's health care system for two reasons. First, I needed to receive medical consultation on a sports injury which would probably require surgery. Second, I thought that as a Health Care Administration Resident I needed to see how the system works from a patient's point-of-view. The first part of my health care experience required me to obtain a primary care appointment through central appointments. After being put on hold by an appointments clerk and waiting for thirty minutes to schedule a primary care visit, I decided to hang-up and return to an afternoon of scheduled residency visits. The next morning I went to the Family Practice Clinic during walk-in hours to obtain a primary care evaluation. The primary care provider subsequently gave me a referral to the Surgical Clinic for a specialty evaluation which I decided to take care of that day. This sequence of events ultimately led to a scheduled pre-admission processing date and a scheduled surgery date. My personal health care experience for accessing a primary care provider and obtaining consultation from a general surgeon is outlined in Table 1 on the next page.

Table 1
Primary and Specialty Care Consults

0730	Signed in at Family Practice Clinic
0732	Wait
0740	Vitals
0745	Wait
0825	Primary care received
0830	Received consult, traveled to Surgical Clinic
0832	Signed in at Surgery Clinic
0835	Wait
0930	Specialty care visit by intern
1000	Wait
1100	Specialty care visit by surgeon
1110	Wait
1200	Scheduled surgery date, then traveled to the pre-admission office
1210	Wait
1215	Made date for surgery and a preceding pre-admission visit at the Ambulatory Surgery Unit
1220	Completed the process

On January 13, 1995 I reported for pre-admission processing which was ten days prior to the scheduled surgery date. In all, it took three hours and twenty-three minutes to complete the pre-admission process, of which I waited three hours and five minutes. On January 23, 1995 I reported to the ASU for surgery. In short, I waited five hours only to be told that my surgery had to be cancelled due to unexpected emergencies in the operating room. The sequence of events for my pre-admission processing experience is outlined in Table 2 below.

Table 2
Pre-admission Processing

	Time	Cum. Time
Arrived at the ASU	1300	
Wait	1300-1345	45 min
Anesthesia interview	1345-1355	55 min
Wait	1355-1545	2 hr 45 min
Vitals	1545-1550	2 hr 50 min
Wait	1550-1620	3 hr 20 min
Pre-admission at PAD	1620-1623	3 hr 23 min

Throughout the entire process I either removed my hospital identification badge or presented myself at scheduled appointments in civilian clothes so that I would not receive any special attention, and so that I could see first-hand how the system works from a patient's perspective. Given the knowledge that I have gained during the didactic and residency phases of my graduate level training, along with some professional working experience in a hospital setting, I was able to logically assemble some reasons why the pre-admission process was so inefficient. The primary reason for such systemic problems exists because the process involves participation from several different organizations without a single person managing all activities. From the perspective of patients without any working experience in the health care industry, the ASU is unorganized and inconvenient to them and their employers/family. Whatever perspective a patient has, the pre-admission process at Womack is frustrating.

I decided to approach LTC Ciresi and ask him if I could become part of his team to restructure the pre-admission process. I thought that I could offer valuable input to the process from a patient's point-of-view and from an operational research perspective. The team I became a part of involved players from several different technical functionalities which include the Department of Nursing, the Department of Surgery, the Laboratory Service, Cardiology, Radiology, and the Patient Administration

Division. The implementation date of the new pre-admission process was March 6, 1995.

Statement of the Problem

In order to provide patient-focused care that is both efficient and effective, Womack must continually assess and improve internal processes. This philosophy of continuous improvement inevitably introduces operational concepts which require a change from normal procedures. To create change in an organization that is structurally complex and is increasingly constrained by budgets, it is imperative that managers quantify the changes they intend to make through operations analysis and computer simulation.

This project is a two-part comparison study which first involves the statistical analysis of two systems (Status Quo and Alternative #1) using actual patient processing times to identify performance improvements before and after the introduction of change. Then I will concentrate my comparison study on the development of three computer simulated models (Status Quo, Alternative #1, and Alternative #2) to replicate actual performance in the Status Quo and Alternative #1, and recommend process enhancements with Alternative #2 to further improve system performance based on inefficient components of the existing pre-admission process. The processing times and descriptive statistics collected from actual patient surveys will become the basis for the operands, or parameters, used to build

the three computer simulated models. The computer generated data for the three models will then be statistically compared to each other to determine which system best answers the problem stated below.

Can the flow of patients in the pre-admission process be restructured from the Status Quo (before March 6, 1995) to Alternative #1 (after March 6, 1995) to decrease the amount of time people have to wait in the system, and then be simulated through the use of a computer software package to further improve the productivity of the existing pre-admission process (Alternative #1) in the future using a second alternative?

Literature Review

The preparation of patients for surgery has always been an accepted part of the nursing role. The responsibilities associated with this pre-operative process have steadily expanded along with the technical evolution of the nursing profession (Oetker-Black 1993). This literature review will outline the evolution of the pre-admission process over the past century. Then, I will discuss the importance of computer simulation in a competitive health care market where cost efficient decisions based on a quantified process analysis will be the difference

between financial success and failure for businesses in the future.

Between 1900 and 1920, Louis Pasteur revolutionized the science of medicine with his research in the area of bacteriology. During the same time period, Abraham Flexner uncovered a lack of educational standards in the United States. The Flexner Report significantly affected the supply of physicians in America, and ultimately improved medical school standards (Oetker-Black 1993).

By 1915, only ten percent of the people in the United States received medical care in hospitals. However, there was a public health movement emerging nationwide which led to an increased demand for nursing services. Surgical procedures of the time occurred mostly in the home, and physicians relied upon nurses for the physical and emotional preparation of patients. It was the nurses responsibility to win the patient's confidence over a lengthy preparation period that covered a few weeks and involved the physical conditioning of one's body for surgery. The nurse was also responsible for establishing a clean surgical environment, and providing constant reassurance to the patient (Oetker-Black 1993).

From 1920 to 1940, the physician's "work-shop" shifted from a black bag and a home-based atmosphere to the hospital. During this time, sixty-seven percent of physicians were affiliated with a hospital staff appointment. The standards for nursing care evolved somewhat in that consideration was given to the emotional

needs of the patient and their families. Physical preparation included a reduction in the number of preoperative admission days from four to one, and the elimination of food the night before surgery. Nurses continued to act solely on directives given by physicians and had not yet gained any professional independence. However, with the introduction of a 1938 publication written for the nursing profession and outlining general anatomy and physiology functions, medical and surgical treatments, and specific clinical interventions, nurses began to gain some autonomy in health care (Oetker-Black 1993).

Between 1940 and 1960, the nursing profession became a more complex service which focused on the education of surgical patients. This concept of education centered around the psychological preparation of patients through reassurance and the familiarization of hospital procedures. Nurses were also expected to understand the disease process so that post-operative treatments would play a large role in the speedy recovery of surgical patients (Oetker-Black 1993).

Technology advanced dramatically between 1960 and 1980. With an advance in technology, came the emergence of nursing research. This research began to document the idea that effective pre-operative preparation leads to a more rapid post-operative recovery. One study documented an observation that those patient's who were confident and had low levels of anxiety before surgery tended to be more anxious after surgery. Conversely, those patient's most anxious before surgery tended to

cope better post-operatively because they used the pre-admission testing period as a rehearsal which motivated them to ask for more information. The study suggested that by structuring a formal pre-operative process with greater emphasis on individual needs and pre-operative instruction, nurse researchers were able to "validate the link between pre-operative preparation and post-operative recovery (Oetker-Black 1993)."

Since the early 1980s, and with the federal government's implementation of a prospective payment system for Medicare beneficiaries, the health care industry has had to become concerned with minimizing costs to make a profit. The industry's philosophy changed in the mid-1980s from a system that was generally reimbursed on a cost-basis by third party payors to one that was given a fixed, predetermined reimbursement rate for a given DRG. The result has been to focus on decreasing length of stays, minimizing costs to the organization, and ultimately leaving enough profit in the end to remain financially successful (Sabin 1985). It was not until the early 1990s that the military began to establish budgets that were based on a capitated methodology. Before then, military health care budgets were dependent upon the number of work units produced. Consequently, no emphasis was placed on cost control or the minimization of demands on scarce resources. In simple terms, the more volume you generated, the more money you received (OSD-HA 1994).

The evolution of pre-admission processing standards within the last twenty years has been shaped by the regulation of health

care reimbursement. The reason for the organization of dedicated pre-admission testing centers over the years has been to contain the escalation of costs and decrease average length of stays in an effort to increase operational efficiencies thereby improving the organization's long term financial viability. There are generally seven initiatives associated with the use of pre-admission units since 1980. They are listed below and explained in the succeeding paragraphs. The explanation of these initiatives are organized to develop the progress of PAUs in several areas since 1980, not to give the reader a chronological arrangement of issues during the same period.

a. To decrease anxiety.
b. To increase quality.
c. To improve recovery rates.
d. To decrease length of stays.
e. To increase employee cooperation.
f. To increase revenues.
g. To decrease waiting lines and increase patient satisfaction.

Linda Dixon, an ENT Unit Manager, found out through a patient satisfaction survey that ninety-six percent of her patient's who processed through a pre-admission clinic experienced reduced anxiety. This was achieved through the provision of educational information, psychological preparation,

and ancillary testing (Dixon 1994). In another survey by The Baxter Foundation, seventy-seven percent of the patients interviewed felt that their anxiety for surgery decreased by talking with a surgeon during a pre-admission interview. Furthermore, forty-two percent of those who talked to nurses, fifty-six percent of those who spoke to a physician's assistant, fifty percent of those who viewed a videotape, and forty-three percent of those who read a brochure during the pre-admission process felt that they were less nervous about surgery (Pedersen 1991).

The implementation of pre-admission testing has been found to increase the quality of medical care by detecting health abnormalities before the scheduled surgery date, and by avoiding surgeries that were simply unnecessary. Sherif E. Habib completed a seven month study involving 245 patients and found that approximately three percent of the patients that processed through a pre-admission clinic had health abnormalities which postponed their surgery, and eight percent of the patients did not need surgery as a result of ancillary test findings (Habib 1993). In a 1992 study, thirty-one percent of the patients scheduled for orthopedic surgery were found unfit during the pre-admission testing phase. Five percent of those found fit for surgery on the day of pre-admission testing were found unfit on the day of surgery which could have been avoided if pre-admission tests had been evaluated more closely (MacDonald and others 1992).

From a quality standpoint, pre-admission units have succeeded in their attempt to anticipate and exceed the patient's expectations for surgical preparation. By taking a holistic approach and focusing on the familiarization of the surgical process, the patient's anxiety level was reduced and the recovery period tended to be faster (Holloway and Hall 1992).

A 1984 study on the impact of pre-admission evaluations of elective surgery in a pediatric hospital determined that pre-admission testing significantly reduced the average length of stays by 2.31 days. The study included 100 patients which were compared to a concurrent control group of 167 pediatric patients and 379 historical control patients. The average length of stays were 5.79 for the pre-admission study group, 8.10 for the concurrent control group, and 8.19 for the historical control group (Goldbloom and Macleod 1984).

Two years later, a Utilization Review Committee in a 500 bed university medical center determined that preoperative length of stays were 2.6 days. The major reason identified by the committee for the 2.6 day average before surgery was abnormalities being diagnosed on the day of admission (Smeltzer and Flores 1986). By comparing this study to the one just described in the preceding paragraph, it is probably more than a coincidence that by employing a pre-admission process the overall average length of stays decreased by 2.31 days, and preoperative length of stays due to health abnormalities averaged 2.6 days.

In 1991, a study at The University of Alberta Hospital estimated that the implementation of a pre-admission program reduced overall hospital length of stays by approximately one day (Allison 1991). As stated in a New England Journal of Medicine article during the same year, the findings of a cost containment study suggest that the era of significantly reducing length of stays and their associated costs, is largely over. The study goes on to say that even as trends continue to project increasing ambulatory care visits in the future, the net savings will be statistically insignificant. Most of the "fat" associated with length of stays has largely been eliminated, and any further significant decreases will only come as breakthroughs in medicine and technology occur (Schwartz and Mendelson 1991).

In addition to reducing anxiety levels, increasing patient satisfaction, increasing quality by detecting health abnormalities, improving the rate of surgical recovery, and an increase in cost savings due to decreased average length of stays, the implementation of dedicated pre-admission units have been shown to improve employee cooperation. In essence, employees tend to assume responsibility for pre-admission patients if their abilities are dedicated to a specific process. The organization of dedicated pre-admission sites also eliminates the need for patients to wait in line at ancillary departments, which are often clogged by outpatient referrals from clinics. Probably the most favorable aspect of implementing a dedicated pre-admission test center is that all diagnostic testing that

occurs in a pre-admission setting qualifies for it's own separate DRG reimbursement which increases the amount of revenue generated for the entire episode of care (Sabin 1985).

One assumption that my Graduate Management Project makes is that by reducing overall processing times in the PAU, patient satisfaction levels can be improved. This assumption is supported by many studies in the literature that analyze correlations between satisfaction and waiting times. Of the literature reviewed for this study, patients are generally most satisfied with the technical quality of care and competence of their providers and least satisfied with time spent waiting (Hill and others 1992). The primary reason that time waiting is so often documented as an indication of dissatisfaction is that it is measurable and patients use it to judge performance, even more than a provider's knowledge or skills (Jackson 1991).

These findings suggest that if efficiency can be improved internally, then patient satisfaction levels can be improved. To improve the internal efficiency of the PAU at Womack, patient flow patterns and facility design were restructured. This initiative is similar to redesign efforts of an outpatient pharmacy at a Veteran's Administration hospital to improve work flow, waiting time, and patient satisfaction. Workload data and waiting times were analyzed before and after implementation of redesign efforts and results indicated a decrease from more than one hour to thirty minutes for customer processing time. The study also indicated through interviews of randomly selected

patients that reduced processing times resulting from work flow redesign efforts led to greater satisfaction (Pierce and others 1990).

Purpose Statement

The purpose of this Graduate Management Project is to collect and analyze data from two groups of patients to determine performance improvements before and after pre-admission processing changes. One group of patients will represent those who processed through the PAU before the restructuring effort on March 6, 1995. This pre-admission process is identified as the Status Quo. The second group of patients will represent those who processed through the PAU after restructuring efforts and it is identified as Alternative #1. The patient data collected will then provide the descriptive statistics necessary to simulate three computer models using a software package known as GPSS/H. Two of the models (Status Quo and Alternative #1) will attempt to replicate processing times before and after the introduction of changes in patient flow, and the third model (Alternative #2) will be used to recommend process enhancements to further improve system performance.

"Restructuring efforts" refer to initiatives by the PAU staff to change from block appointment scheduling techniques to individual appointment scheduling techniques. It also includes an initiative that consolidates representatives from admissions,

lab, nursing, EKG, and anesthesia on one floor to improve patient flow and convenience.

I will measure statistical significance two ways. First, to determine the significance between the two patient groups surveyed before and after restructuring efforts. To do this, the mean processing times for the Status Quo and Alternative #1 groups will be tested statistically using a pairwise/one-way comparison test, or a t-test, to see if structural changes actually result in significantly lower patient waiting times. The second measure of statistical significance will be between the three computer simulated models using an analysis of variance test, or ANOVA. This test will identify whether simulated refinements to the PAU process produce mean waiting times which are significantly different.

There are five supporting objectives which further outline the purpose. They are outlined below, described in the succeeding paragraphs, and in no order of precedence.

a. To optimize provider utilization rates.

b. To decrease waiting times ultimately leading to greater patient satisfaction.

c. To create a one-stop/continuous flow pre-admission process.

d. To improve patient familiarity with the surgery process.

e. To sustain the ability to identify abnormalities in one's health before the surgery date.

Utilization rates refer to the percentage of time that provider's are fully engaged in providing direct patient care. For example, if an Anesthesiologist is scheduled for 60 minutes to provide interviews for pre-admission patients, and he/she provides only one session which takes six minutes. His/her utilization rate for that hour scheduled would only be 10 percent which is a very valuable resource underutilized. So, it is my intent to identify utilization rates for providers like nurses and anesthesiologists that are low, and use a computer simulation software package known as GPSS/H to devise viable alternatives to modify the process.

The second supporting objective is to improve patient satisfaction by decreasing waiting times. Patient satisfaction will not be directly measured, yet I have made the assumption based on studies cited in the literature review that patients will become more satisfied with their surgical experience if their time is not wasted by waiting in lines to see a provider. Henceforth, decreased patient waiting times is the primary objective, and satisfaction is secondary or a by-product of decreased waiting times.

The creation of a one-stop/continuous flow approach to the pre-admission process is intended to eliminate block scheduling and patient flow patterns that require people to travel up and down stairs and in elevators. One-stop refers to the consolidation of representatives from admissions, lab, EKG, nursing, and anesthesia on one floor. Continuous flow refers to

a standard pathway for pre-admission patients which eliminates the requirement for patients to receive service from one provider, return to the waiting room --- surgical packet goes into another stack, receive service from another provider, return to the waiting room --- surgical packet goes into yet another stack, and so on. The continuous flow approach allows patients to flow from one service to the next without joining waiting line after waiting line. This approach is enhanced by individual appointment scheduling and is dependent upon a pre-admission process that is free of bottlenecks.

The fourth supporting objective is to increase the patient's familiarity with the surgery process (Oetker-Black 1993). Patient familiarity is improved through educational efforts during the pre-admission process which is optimally scheduled within a window of four to ten days. During this period patients are better able to cope with their expectations realistically and tend to absorb information more effectively if their anxiety level is lower than on the day of surgery (Rost 1991). In other words, if patients are dissatisfied with waiting times and become frustrated with their visit, then all educational efforts to reduce the anxiety that comes with surgery are minimized.

The fifth supporting objective is to continue offering provider's with an opportunity to identify any abnormalities in the patient's health. This opportunity exists when provider's are able to interview patients, review lab tests, and analyze radiographs. If the pre-admission process did not exist and

patients were interviewed and tested only hours before the scheduled surgery date, then the ability of the ASU to minimize costs would be uncontrollable due to cancellations, prolonged pre-operative admissions which increases bed days, and wasted operating room resources caused by cancellations (Smeltzer and Flores 1986).

The null and alternate hypotheses that I will test are presented below. The independent variable is waiting times, a continuous variable. The dependent variable is the scheduling technique used, a binary variable. Zero represents the presence of block scheduling and one signifies the use of individual scheduling techniques.

H_o: There is no difference between $Mean_{Status\ Quo}$, $Mean_{Alt\ \#1}$, and $Mean_{Alt\ \#2}$. There is no systematic relationship between decreased waiting times in the PAU (y) and individual patient appointing techniques (x). The functional expression is that decreased waiting times $\neq$ f(individual patient appointing techniques).

H_a: There is a difference between $Mean_{Status\ Quo}$, $Mean_{Alt\ \#1}$, and $Mean_{Alt\ \#2}$. There is a systematic relationship between decreased waiting times in the PAU (y) and individual patient appointing techniques (x). The functional expression is that decreased waiting times in the PAU = f(individual patient appointing techniques).

CHAPTER 2

METHOD AND PROCEDURES

Flow Charting the Pre-admission Process

The first step in the data collection process involved the documentation of patient flow relationships from the clinic requesting pre-admission testing, through the PAU for testing, to the Ambulatory Surgery Unit on the scheduled date of surgery. The graphic portrayal of the three processes I analyzed are presented in the form of flow charts at Appendix 1 for the Status Quo and Appendix 2 for Alternatives #1 and #2. Alternatives #1 and #2 are expressed using the same flow chart because patient flow is essentially the same with the exception of establishing radiological testing services on the same floor as all other services in Alternative #2. The other difference between the two alternatives is that I introduce performance objectives, or productivity indicators, to control for variation in processing times in Alternative #2. The three pre-admission process flow charts are discussed in the following paragraphs and graphically portrayed in Appendices 1 and 2.

Status Quo

Womack operates access to care through a gatekeeper or a primary care provider. Appointments from primary care providers to the appropriate specialty clinic are made by Health Care Finders. When the patient presents himself/herself for their scheduled appointment at the specialty clinic (refer to Appendix

1), the provider determines the appropriate mode of treatment. If the decision is for surgery and the patient consents, then the physician identifies a projected surgery date and a case length. If surgery is not necessary then the episode of care is completed and the patient is given instructions for subsequent care which could be a follow-up appointment or the use of prescribed medications.

Once a projected surgery date and case length are determined, then administrative personnel within the clinic are given physician orders which provide them with instructions for assembly of a surgical packet. The patient is given an information sheet along with a partially completed surgical packet by administrative personnel within the specialty clinic. The information sheet explains the pre-admission process, and the partially completed surgical packet contains a history and physical, a copy of the operating room scheduling or 'buck' slip, and the physician's orders. If further outpatient referrals are required by the specialty physician before pre-admission processing then the patient is given a consult to the specific service. The rectangular box and directional arrows on the graphic identifying an outpatient consult is dotted because it is not a required part of the process.

The patient is then instructed to travel to the PAU to schedule a pre-admission test date within a four to ten day window before the scheduled surgery date. At Appendix 1 this symbol is in the shape of an oval because it requires patient

compliance before the rest of the process can continue. The surgical packet is completed by PAU personnel by placing blank test forms and previous ancillary tests that apply to the case in it.

The next part of the process signifies arrival of the pre-admission appointment. Again, it is purposely designed in the shape of an oval because it requires patient compliance before the rest of the process can continue. If the patient does not arrive for the scheduled appointment, then he/she must attempt to reschedule with the PAU clerk. If the rescheduled appointment does not fall within the required four to ten day window before the date of surgery, then the patient must continue back to the specialty clinic to reschedule another surgery date with the physician. If the patient arrives for the scheduled appointment, then pre-admission processing begins.

It is important to note that completion of specified pre-admission stations in all process flow charts are fully dependent on a physician's orders. For the purpose of this study, I will represent anesthesia, nursing, and admissions stations as a solid symbol since a majority of PAU patients process through them. The symbols that represent radiology, lab, and EKG testing are displayed using dotted graphics since they are not a normal part of the pre-admission process for all PAU patients.

After a patient arrives for his/her pre-admission appointment and checks in with the PAU clerk, he/she is asked to sit in a waiting area before processing through the first

required station which is an interview with a representative from Anesthesiology. An operating room/anesthesia video tape, which was produced by Fort Bragg technicians and includes Womack employees, is played at this time to provide supplemental information to the patient concerning their surgical experience. Every patient, with the exception of those scheduled for endoscopic or minor procedures, has to see an anesthesiology staff member to receive counseling on the best type of anesthesia for their particular procedure.

After an anesthesia interview, the patient is told by the provider to return to the waiting area before processing through the next station, nursing. Each patient has to receive counseling by a nursing staff representative to obtain vitals and basic medical history information not previously documented by the specialty clinic, admissions, or the PAU administrative staff. Once again, the provider is responsible for instructing the patient to proceed to admissions or return to the waiting area before proceeding to the next testing station.

The location of the next station depends on physician orders. If a lab, EKG, or radiology test is required then the patient travels to any or all of them in accordance with probabilistic decisions made individually or by the PAU staff. The rectangular boxes and directional arrows in the process flow diagram are dotted for the same reason as the outpatient consult explained above, to identify a step that is not necessarily a required part of PAU patient flow. The box signifying radiology

is three dimensional because it is not on the same floor as the rest of the PAU processing stations.

The last step required for pre-admission processing in the Status Quo system is admissions. It exists to ensure eligibility requirements, insurance information, and general demographic data needed for patient identification, control, and medical records documentation. Between the pre-admission date and the surgery date, the PAU staff has the responsibility to consolidate the results of tests so that anesthesiologists and surgeons can review them to identify any abnormalities which would prevent the surgery from taking place.

Assuming that all test results are normal, the patient is expected to call one day prior to the scheduled surgery date to receive a reporting time. This time is a consequence of the prioritization process which is completed by the operating room nursing staff. The oval specifying the arrival of the surgery date is given its shape because it requires patient compliance before the process can go any further. If the patient shows up for surgery as scheduled, he/she reports to the Ambulatory Surgery Unit (which is operated by the same administrative staff as the PAU) and waits for the nursing staff to begin pre-operative preparations. After surgery, the physician makes one of two decisions. One decision would be to release the patient on the same day of surgery, and the other would be to admit the patient to a ward. These two actions are graphically portrayed

on the diagram as modified rectangles to signify completion of the surgical procedure.

If the patient does not report on the day of surgery, then the procedure is cancelled. The patient is then required to report to the originating specialty clinic and surgeon to reschedule another surgery date. If a second date is scheduled within 30 days of previous pre-admission testing, then another PAU appointment is unnecessary. The only requirement is for the surgeon to send a scheduling or 'buck' slip to the operating room. If the rescheduled surgery date is outside thirty days then an additional pre-admission testing date must be scheduled to ensure that no abnormalities exist in a patient's condition that prevents an operation.

Alternatives #1 and #2

The flow of patients in Alternative #1, which was implemented March 6, 1995, and Alternative #2 are both portrayed graphically at Appendix 2. Again, Alternatives #1 and #2 can be expressed using the same flow chart because patient flow is essentially the same with the exception of establishing radiological testing services on the same floor in Alternative #2. The other difference is that I introduce performance objectives, or productivity indicators, to control for variation in processing times in Alternative #2.

The distinguishing characteristics of the two pre-admission alternatives with the Status Quo model and among each other are

listed below and explained in the paragraphs that follow. Be forewarned that some of the dynamics associated with patient flow processing for the Status Quo, Alternative #1, and Alternative #2 are better understood by reviewing the scripted computer simulation models found at Appendix 5, 6, and 7, respectively, instead of reviewing the flow charts. To guide the reader through this dynamic, I have ended each paragraph in this section by referring to the appropriate appendix. Differences among the models included:

a. Individual versus block scheduling techniques.

b. All pre-admission services on one floor.

c. Patient focused scheduling concepts since specialty clinics schedule pre-admission appointments.

d. Probabilistic decision making options to provide flexibility for patients and the administrative staff.

e. Performance objectives (productivity indicators) to control for variation in outcomes.

First, four patients are scheduled individually every hour throughout the day in Alternatives #1 and #2. The Status Quo model utilizes a block scheduling technique where twenty patients are given the same appointment time (See Appendices 5, 6, and 7).

Second, Alternative #1 represents a process that locates all pre-admission services on the 2d Floor, except for x-ray testing which is on the 1st Floor. In Alternative #2, I model a system

that incorporates radiological testing on the same floor as all other stations. Prior to consolidating all pre-admission stations on one floor, patient's who processed through the Status Quo model were asked to enter queues for lab, admissions, and radiology testing along with all other ancillary department customers. This led to two processing dynamics. The requirement for patients to access a fragmented health care delivery system with different rules at each stop, and a loss of administrative control by the staff as patients traveled up and down stairs and elevators (See Appendices 1 and 2).

Third, admissions processing was the last station processed in the Status Quo model, and it is the first station processed in Alternative #1 and #2. There is really no operational reason that it is the first station. The critical point is that admissions is on-site in Alternatives #1 and #2 which provides more control over the process by the PAU staff and more convenience for the patient (See Appendices 1 and 2).

The next difference between the two alternative models and the Status Quo is that pre-admission appointments are scheduled by the originating specialty clinics administrative staff via a dedicated telephone line before the patient leaves the office. This places the administrative burden on the clinic staff instead of the patient which eliminates traffic in hallways, frustration by waiting in lines, and confusion as all activities have somewhat contrasting operating procedures. It also encourages the originating clinic to maintain the responsibility for a

patient's total health care experience. In the restructured models a patient is given instructions for pre-admission processing and surgery before leaving the specialty clinic, and within 24 hours a completed packet containing a history and physical, blank lab slips, a copy of the operating room scheduling or buck slip, and physician orders are forwarded by a clinic courier to the PAU (See Appendices 1 and 2).

The fifth difference is that the two alternatives provide more flexibility for the patient to make decisions for testing while maintaining administrative staff control where it is deemed logical. This concept is known as probabilistic modeling when developing computer simulations (Banks, Carson, and Sy 1989). For example, after viewing the operating room and anesthesia video tape, the patient can choose which interview (anesthesia or nursing) to complete depending on the availability of providers (See Appendices 1 and 2).

Administrative staff control is established in the two alternative processes by inserting a control point as the last station to ensure compliance with a physician's orders. This difference also establishes a final check for the administrative staff to provide patients with logistical and medical instructions for the surgery itself, to answer any questions not adequately addressed in the stations processed, and to coordinate any outpatient consults resulting from one of the provider interviews (See Appendices 1 and 2).

The seventh difference is the establishment of performance objectives for the system as a whole and each of its stations. Alternative #2 models this concept, and it is not visually evident by reviewing the patient flow at Appendix 2. Each station is given a time standard in the computer simulation modeling process (Appendix 7) with specified time limits and reduced opportunity for variation. The idea is not introduced in an effort to rush the patient through the system thereby reducing patient waiting times and improving provider utilization rates. The purpose is to provide a heuristic measurement to gauge a process that is supposed to give provider's information on an individuals medical status, reduce the patient's anxiety associated with planned surgery, and operate a system that is efficient and effective (See Appendices 5, 6, and 7).

Timing Interviews

In order to come up with the average amount of time that each individual task in the process takes to accomplish I developed a time collection tool which was given to approximately fifty patients before and after implementation of Alternative #1 on March 6, 1995. It is labeled Appendix 3. As you can see by the chart, I gave each patient a control number and asked them to record the time it took to receive an anesthesia interview, a nursing interview, an admissions interview, lab tests, radiology tests, and EKG tests. Each time annotated for anesthesia, for example, was the actual time in the provider's office and did not

reflect the time spent in waiting rooms. The time that patients spent in waiting rooms was computed by determining the total time spent in the system and subtracting the time spent in the provider's office.

The start time into the system (see Appendix 3, System - In) was annotated as 1:00 p.m. for all patients processing through the Status Quo system. For all patients who processed through Alternative #1, the scheduled appointment time was indicated as the start time (see Appendix 3, System - In). For patients who processed through Alternative #1, the finish time (see Appendix 3, System - Out) which signifies completion of the process, was recorded by the patient at the last station in the process. The last station in the process was admissions for the Status Quo process and the PAU clerk for Alternative #1. Patients were asked to record only times for tasks that they completed on the time collection sheet, and to disregard those tasks that did not apply to their surgeon's orders.

Appendix 4 consolidates all time collection sheets (Appendix 3) into one spreadsheet. The compilation of individual patient experiences during the pre-admission process enables me to compute the descriptive statistics and construct a histogram for both sample groups (Appendix 10).

The Three Computer Simulated Models

The three computer simulation models at Appendix 5, 6, and 7 replicate in simple programming language what the flow charts

displayed in graphic form. I have chosen to model the Status Quo and Alternative #1 (Appendix 5 and 6, respectively) in order to replicate the two processes. Alternative #2 exists to further refine the restructured pre-admission process using identifiable performance objectives, or productivity indicators, so that future health care administrators can make informed decisions based on quantifiable research findings. The numbers used in the operands column of each model for the mean and standard deviation were derived during the data collection period from actual patients. These descriptive statistics can be found in Appendix 4.

I have programmed several 'transfer' statements in each model to depict the fact that not all patients process through each station. The percentages for the transfer statements were derived from the data I obtained from patients during the collection period, and they too can be found in Appendix 4. I decided to run three terminating iterations for each model because the PAU does not operate continuously, and because three iterations on GPSS/H provides a manageable amount of information from which to draw management decisions.

The Status Quo model (Appendix 5) generates twenty patients which exemplifies the actual number of patients block scheduled before restructuring initiatives. It identifies four storage blocks where there are two anesthesia servers, three servers for admissions, five servers for lab testing, and two radiology

servers. The process is deterministic in that each transaction is executed in sequence.

The first alternative (Appendix 6) is the same process that was implemented on March 6, 1995 to replace the Status Quo. It was developed by the Registered Nurse Anesthetist (RNA) in charge of the PAU, LTC Ciresi and an interested group of people representing a variety of clinical and administrative specialties. The model simulating Alternative #1 depicts a change in the way patients are scheduled. The Status Quo model simulated the block scheduling technique, and Alternative #1 simulates patients that are generated every fifteen minutes for 420 minutes or a seven hour day (one hour lunch). This depicts the concept known as the individual appointment scheduling technique. Alternative #1 has one storage block for radiology testing. All of the other storage blocks programmed for the Status Quo were eliminated when representatives for each facility were consolidated on one floor. I decided to program this alternative, as well as the next, in a deterministic fashion for one major reason. The one-stop/continuous flow concept of providing pre-admission testing was established to create a fluid movement of patients through the system. Even though patients and the PAU staff have the ability to access idle providers or make probabilistic health care decisions, I feel that it is more important to identify 'bottlenecks' in the system as it was designed.

Alternative #2 (Appendix 7) is a process devised by me and it builds upon the first alternative's concept of using individual appointment scheduling techniques to decrease patient waiting times. Alternative #2 incorporates some additional productivity enhancements and performance objectives to further decrease waiting times and control the variation that occurs in the Status Quo and Alternative #1 models. The first enhancement is to place an x-ray machine on-site, along with all other stations, with a dedicated representative to process all requests for PAU patients needing radiology tests. This enhancement is currently seen as cost prohibitive and a replication of costly resources, but as health care continues to move toward outpatient alternatives due to cost containment initiatives and technological innovations it will become a reasonable solution to increased demand on PAU services especially as the opening of the new Womack facility nears (projected opening date is January 1999).

The second enhancement to Alternative #1 found in Alternative #2 is to establish some performance objectives, or productivity indicators, for provider's within the process. For instance, I modeled a process that gives anesthesia and nursing interviewers fifteen minutes, and lab/EKG/PAD representatives ten +- five minutes for each patient. The idea of performance objectives is not to rush patients through in an assembly line approach, but to give direct care providers a heuristic measurement to gauge their productivity throughout the workday.

Form of Results

I will compare four portions of the simulation output to quantify the differences between the Status Quo model which block scheduled twenty patients at once and Alternatives #1 and #2 which individually schedule one patient every fifteen minutes. They are:

a. The average utilization of facilities and storage entities

b. Maximum contents

c. Average contents

d. Average time per unit

The "average utilization during" output will show the rate at which each provider in the process was engaged in direct patient care. The "maximum contents" output depicts the maximum number of patients in the waiting line when the queue is at its highest level. The "average contents" shows the average length of waiting lines, or the normal existence of queues throughout the system. The "average time/unit" identifies the average processing time per patient in the system and within each component of the system. These times will be indicated in terms of minutes, and they will be captured by using 'queue' commands in the simulation language itself.

Model Verification and Validation

The output generated by the computer simulation is reasonable and the program seems to work as intended. The primary determinant of this statement lies in that I began building each program simply and added complexity. As I added complexity I continually compared the output to my survey findings during the data collection period and my personal experience in the system as a patient.

The only portion of the simulation's output that is not reasonable is for the 'utilization rate of providers' in the Status Quo model. This is due to the way transactions or patients are decremented. For example, when twenty patients are generated in this model they process through the storage block labeled 'RNA' first. The queue of twenty is steadily decremented one by one until all twenty patients have processed through the anesthesia interview. At that time, the two RNA interviewers can be utilized somewhere else either clinically or administratively. However, the simulation clock continues to build and will not stop until the last patient is processed through the final station. Consequently, the utilization rate for RNAs will appear lower than normal in the model simulating the Status Quo. The utilization rate of provider's becomes useful when the system is restructured and simulated using individual scheduling techniques as modeled in Alternatives #1 and #2.

The two samples representing the actual data collected for the Status Quo and Alternative #1 have significantly different

mean waiting times (t=4.64, p<.0005). There is also statistical significance between the three computer simulated models (F=23.74, p=.0014). Both of these statistical outcomes are favorable since the results suggest that decreased patient waiting times are a function of the introduction of individual scheduling techniques, a restructured patient flow, and the addition of performance objectives. However, where it would be favorable in this study to suggest that there is no statistical significance between the empirical and computer simulated data, the data does not support this hypothesis. In fact, the statistical difference between the empirical and computer simulated Status Quo data is significant where t=4.287, p=.0001. The statistical difference between the empirical and computer simulated Alternative #1 data is also significant where t=6.46, p<.0001. Therefore, the accuracy or face validity between the data collected from actual patients and the data collected through computer simulation is not favorable for this study.

I caveat this finding with two issues. First, the degree of variation is extremely large in the empirical findings documented in Appendix 10. Any time the degree of variation is large, population projections must be used with caution. This is why I explore the reduction of variation using performance objectives, or productivity indicators, in Alternative #2. Second, the average processing times for the Status Quo and Alternative #1 from actual patient surveys (SQ=135 min, Alt#1=80 min), computer simulated findings (SQ=188 min, Alt#1=123 min), and personal

health care experiences (SQ=203 min) are within logical limits. The data also compares similarly to the pre-admission process at Cape Fear Valley Medical Center in Fayetteville, N.C. where it takes an average of three hours to process a patient through the system (Glass 1995).

Constraints and Assumptions

The data collection period was the only constraint to this study. I decided to change the topic of my GMP around March 1, 1995. During the week of February 27, 1995 I collected data on the Status Quo system, and during the week of March 6, 1995 I collected data on the system known as Alternative #1, or the restructured system.

This two week data collection period is seen as a constraint for two reasons. First, I had only one week before the PAU was restructured to collect processing times from patients which resulted in a sample size of 25 patients. Second, I decided to collect data on the restructured process, Alternative #1, during the week of March 6, 1995 because my interim objective was to submit my GMPP before reporting to the Ranger Course. Collecting data during the week that a new system is being implemented is not optimal, yet I was able to obtain sample processing times from 31 patients. The positive and somewhat contrasting perspective of this constraint is that I collected data on the restructured process at its most inefficient point. Consequently, the processing times collected from patients would

only improve as the staff becomes more familiar with operational changes to the system.

I make two assumptions which are supported through research studies documented in the literature review section of this paper. First, I assume that Womack patient's will become more satisfied if waiting times decrease as a result of implementing Alternative #1 or #2. Second, the ability of provider's to identify abnormalities in a patient's health before the surgery date will be unchanged as a result of restructuring efforts and scheduling modifications.

CHAPTER 3

RESULTS

The histogram in Appendix 10 represents a normal distribution for the Status Quo and Alternative #1. These figures represent data obtained from surveys given to actual patients between February 27 and March 10, 1995. The histogram, generated by Microsoft Excel 4.0, portrays the number of patient occurrences for both processes that fall within a specified number of minutes. In the Status Quo model, for example, you can see that eight of the twenty-five patients surveyed processed the PAU within 101 and 150 minutes. As for Alternative #1, twenty-one of the thirty-one patients surveyed processed through the PAU within 51 and 100 minutes.

Appendix 10 also provides a summary of the descriptive statistics associated with both sample populations. As you can see, the mean processing times for the Status Quo (mean=135) and Alternative #1 (mean=80) fall within 101 - 150 and 51 - 100 minutes, respectively. This represents a forty-seven percent reduction in the time that patients have to wait in the system. Statistically, this result (see Appendix 9, all statistics computed using Microsoft Excel 4.0) is highly significant where $t=4.63$, $p<.0005$. The standard deviation of both samples exemplifies a large variation of sixty-two for the Status Quo and thirty-four for Alternative #1.

To further understand where these numbers came from refer to the bottom few rows in Appendix 4 which is two pages long. The

first page is a matrix delineating data collected for the Status Quo and the second page delineates Alternative #1. As shown, the mean and standard deviation for both models is the same as the descriptive statistics table in Appendix 10. The research significance of the numbers presented in Appendices 9 and 10 is that they directly relate to the numbers I used to establish parameters in the three simulated models.

After successfully modeling and "running" the three processes (SQ, Alt #1, and Alt #2), I decided to consolidate the results into one graphic, labeled Appendix 8, to facilitate my ability to compare and contrast the differences between the three computer simulated model outcomes. The four portions of the GPSS/H output that I have chosen to highlight are outlined in the tables entitled Average Time Per Unit, Maximum Contents in the Queue, Average Contents in the Queue, and Utilization Rate of Providers.

In the top most table you can see that the mean processing time for each model simulated decreases with the introduction of individual appointment scheduling in Alternative #1 and the establishment of performance objectives in Alternative #2. The standard deviation associated with the computer simulated Status Quo model (SD=7) is not as large as the survey data collected just before PAU restructuring efforts during the week of 27 February, 1995 (SD=62, see Appendix 4). On the other hand, the variance associated with the computer simulated Alternative #1 model (SD=41) does compare favorably to actual patient data

collected just after PAU restructuring efforts on March 6, 1995. Alternative #2 shows a further reduction in the time patient's have to wait during the pre-admission process to fifty-three minutes. It is indisputable that zero deviation is an unlikely outcome for a system that is highly dependent on human involvement and the dynamics of medical care. However, it signifies the concept that by decreasing the variation associated with a process by establishing performance objectives, you can improve internal efficiencies.

The table entitled 'Maximum Contents in the Queue' depicts the maximum number of patients in the waiting line when the bottleneck is at its highest level. Overall, the maximum system queue contents decreases as productivity enhancements are made to the model. With the introduction of individual scheduling, the maximum number of patients in the PAU system equals seventeen. This drops by more than fifty percent when performance objectives are added in Alternative #2. As you inspect the maximum contents associated with the components of the process, you can see that the levels approach their optimal level of one in Alternative #2.

The table entitled 'Average Contents in the Queue' shows the average length of waiting lines throughout the system. By inspecting the rows and columns separately, the individual component averages bring some notable issues to attention. The first issue comes to focus by inspecting the rows where all averages appear to be decreasing except for the anesthesiology station. The second issue involves the apparent underutilization

of administration, lab, x-ray, EKG, and PAD. In fact, the EKG station does not even register a number until the third decimal place. Theoretically, the optimal 'average contents in the queue' in a system that processes four patients per hour and has seven stations would be .57 per station. However, it seems illogical to place the same emphasis on administration processing as anesthesiology interviews. The answer to the optimal average of patients in the queue lies in the proper utilization of providers which is highlighted in the next paragraph.

As a manager, you would attempt to develop processes that have utilization rates of eighty-five percent. That way people would have time for events not directly related to patient care such as meetings, walk-ins, personal needs, and uncontrollable variables. By comparing Alternatives #1 and #2, it appears that utilization rates have gone down or stayed the same, except for the anesthesiology station. It is also apparent that not only have utilization rates decreased for a majority of the provider's, but they have never approached eighty-five percent. The anesthesiology trend is good since their utilization of providers is given more weight than any of the others. However, it is not the sole intent of this study to optimize the use of anesthesiology staff members at the expense of all other provider's. In the discussion portion of this paper I will discuss the concept of combining administrative tasks such as administration and PAD, and ancillary tasks such as lab/x-ray/EKG to form a team oriented approach to patient care.

Statistically, the mean waiting times produced by the the three simulated models are statistically different where F=23.74, p=.001411. These computations are presented in Appendix 9 in the table summarizing an analysis of variance between three computer simulated models. The analysis tool used to compute the figures was Microsoft Excel 4.0.

CHAPTER 4

DISCUSSION

There is a systematic relationship between decreased waiting times and the utilization of individual patient appointing techniques. Therefore, I reject the Null Hypothesis and accept the Alternate Hypothesis. In both of the patient data surveys that I conducted between 27 February and 10 March, 1995 ($t=4.64$, $p<.0005$), and the three computer simulation models I generated using GPSS/H ($F=23.74$, $p=.001411$), there were statistically significant causal relationships between the groups.

Before restructuring efforts took place on March 6, 1995 it took patient's an average of two hours and fifteen minutes according to actual patient survey data (Appendix 10, Status Quo) to process through the pre-admission process at Womack. According to the same patient survey data, these patient waiting times ranged from thirty minutes to four hours and fifteen minutes in the Status Quo system where twenty patients were block scheduled at 1:00 p.m. daily. As a consequence of twenty patients arriving for the same service at once (actually one

patient arrived early ... 11:00 am ... for reasons unknown), the first person in line was attended to very quickly, and the twentieth person in line was asked to sit patiently for four hours.

After restructuring the PAU process to include the establishment of individual appointments every fifteen minutes throughout the day, and the consolidation of all services (except Radiology) on one floor, patient's were again surveyed to determine the mean processing time (Appendix 10, Alternative #1). The result was a forty-seven percent improvement in the system which decreased the average pre-admission processing time to one hour and 20 minutes.

The primary concern of being able to use the data collected to confidently simulate the Status Quo and Alternative #1 using a computer software package was the high degree of variance associated with each sample group. Nonetheless, the high degree of variance computed using actual patient data and documented in Appendix 10 is a true portrayal of the internal efficiencies that exist in the pre-admission process. In order to improve my ability to predict outcomes, I decided to create Alternative #2. The only programming change I made in Alternative #2 that was different than Alternative #1 was to establish performance objectives by setting specified time limits for each processing station with little room for deviation.

The establishment of performance objectives resulted in a fifty-seven percent process improvement where average processing

times were reduced to fifty-three minutes. Whereas the maximum number of patients in the queue were also brought down to a manageable level, the average contents in the queue and utilization rate of providers suggested an underutilization of providers. This finding implies that perhaps Alternative #2 is modeled to handle situations where surges or patient demands for services are high.

Specific to utilization rates of providers, Alternative #2 produced outcomes where provider's from PAD (67%), lab (31%), administration (20%), x-ray (2%), and EKG (less than .00%) were highly underutilized. If this dilemma concerning underutilization were specific only to Alternative #2 then I would have had reservations about this model as a viable alternative. The underutilization of administrative and ancillary provider's was prevalent in all models. The logical solution to this problem is to create a team oriented approach to the entire system where PAD assists administration in the completion of their duties, the lab and cardiology personnel become cross-trained in rudimentary tasks like drawing blood and applying EKG leads to patient's, and anesthesiology and nursing interviewers eliminate duplicative tasks such as health assessment questions.

Just as the utilization rates of providers representing lab, x-ray, and EKG services are too low, the utilization rate of the nursing facility is too high. As a manager, you cannot expect any individual to work at 100 percent productivity rate for an

entire day. It is just not a realistic expectation no matter how motivated the individual. The logical solution would be to shift workload to another facility in the process, or provide more manpower within the station. I believe that shifting or reorienting the workload is the answer, and this can be done by establishing a process team leader in charge of cross-training personnel, cross-leveling workload, and eliminating duplicative tasks that are commonly found in administrative requirements.

The bottom line is that the establishment of individual appointment scheduling, the employment of a one-stop/continuous flow pre-admission process, and the elimination of block scheduling significantly reduces waiting times for the patient. The key to the continuous improvement of the process in the future is to control for variation. To effectively control for variation decision makers should establish performance objectives or productivity indicators to hold provider's accountable and improve their ability to predict outcomes.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

The flow of patients in the pre-admission process was restructured from the Status Quo to Alternative #1 and it decreased the amount of time people have to wait in the system. Then, each alternative was simulated through the use of a computer simulated package which further outlined a potential improvement in the productivity of the pre-admission process. These findings should be used for future organizational decisions in the PAU.

The implementation of individual scheduling techniques used in Alternatives #1 and #2 and simulated in Appendices 6 and 7 are definitely advantageous to the patient because the time spent waiting in the system decreases from three hours and eight minutes in the Status Quo model, to two hours and three minutes in Alternative #1, and fifty-three minutes in Alternative #2.

I recommend that the PAU partially implement Alternative #2 as soon as possible. I recommend partial implementation because the establishment of performance objectives, or productivity indicators, are the tools necessary to control for the variation that exists in both the Status Quo and Alternative #1 processes. The other part of the concept outlined as Alternative #2 that I do not recommend immediate implementation of is its establishment of radiology assets on-site. Currently, there is not enough workload to warrant the expenditure of money for equipment, facility modifications, and personnel. However, it should be

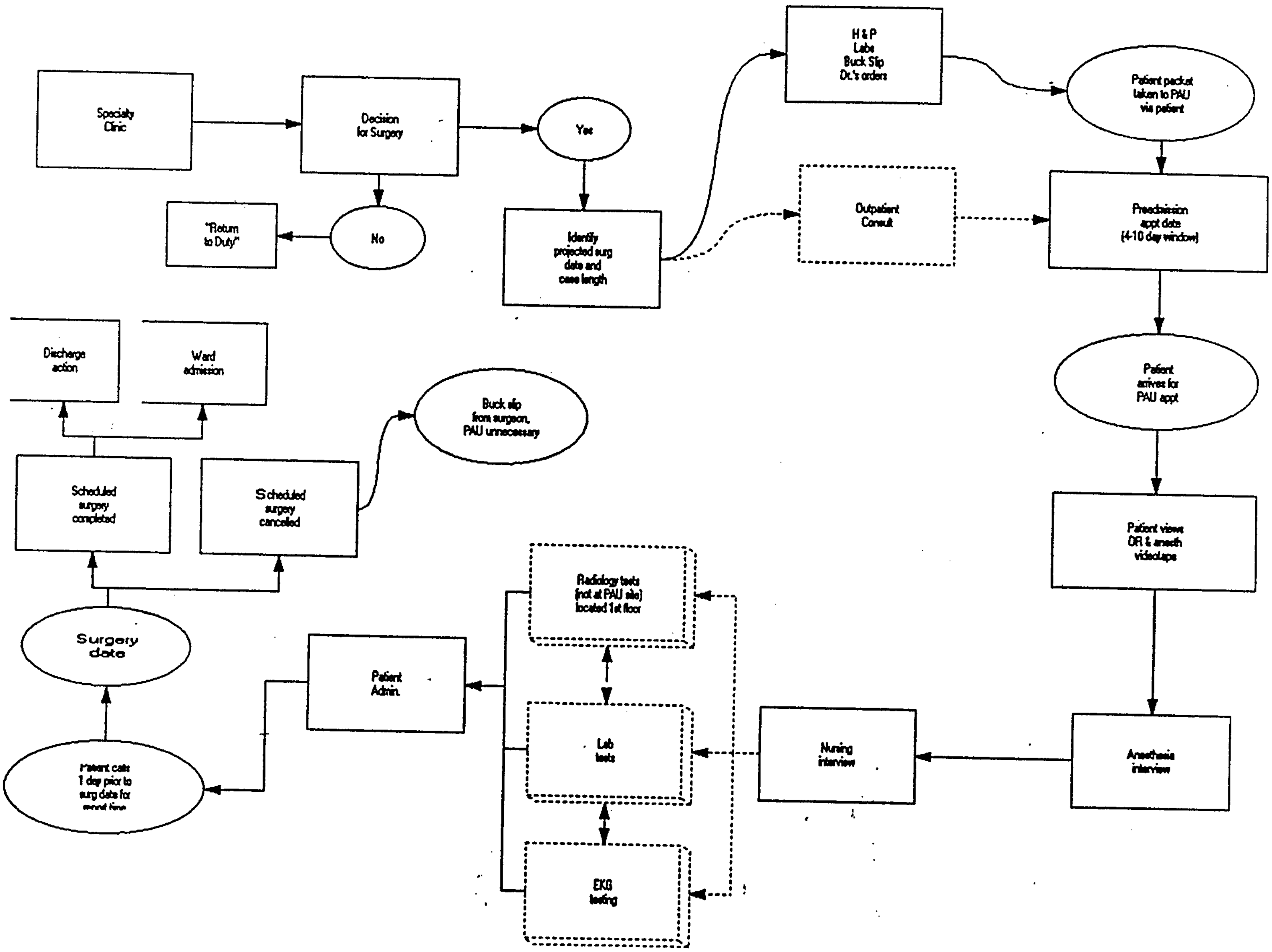
considered as a strategic management alternative in the future in an effort to continuously improve the PAU process. This is especially true as the opening of the new Womack nears and the concept of military medical treatment facilities having to compete for patients develops under TRICARE initiatives.

The creation of change in an organization is normally met with resistance from those who are used to doing tasks one way. However, change was brought about successfully when Alternative #1 was implemented on March 6, 1995 because LTC Ciresi and his team of subject matter experts worked together to find an efficient process that decreased patient waiting times by consolidating all pre-admission services on one floor and changing to individual scheduling techniques.

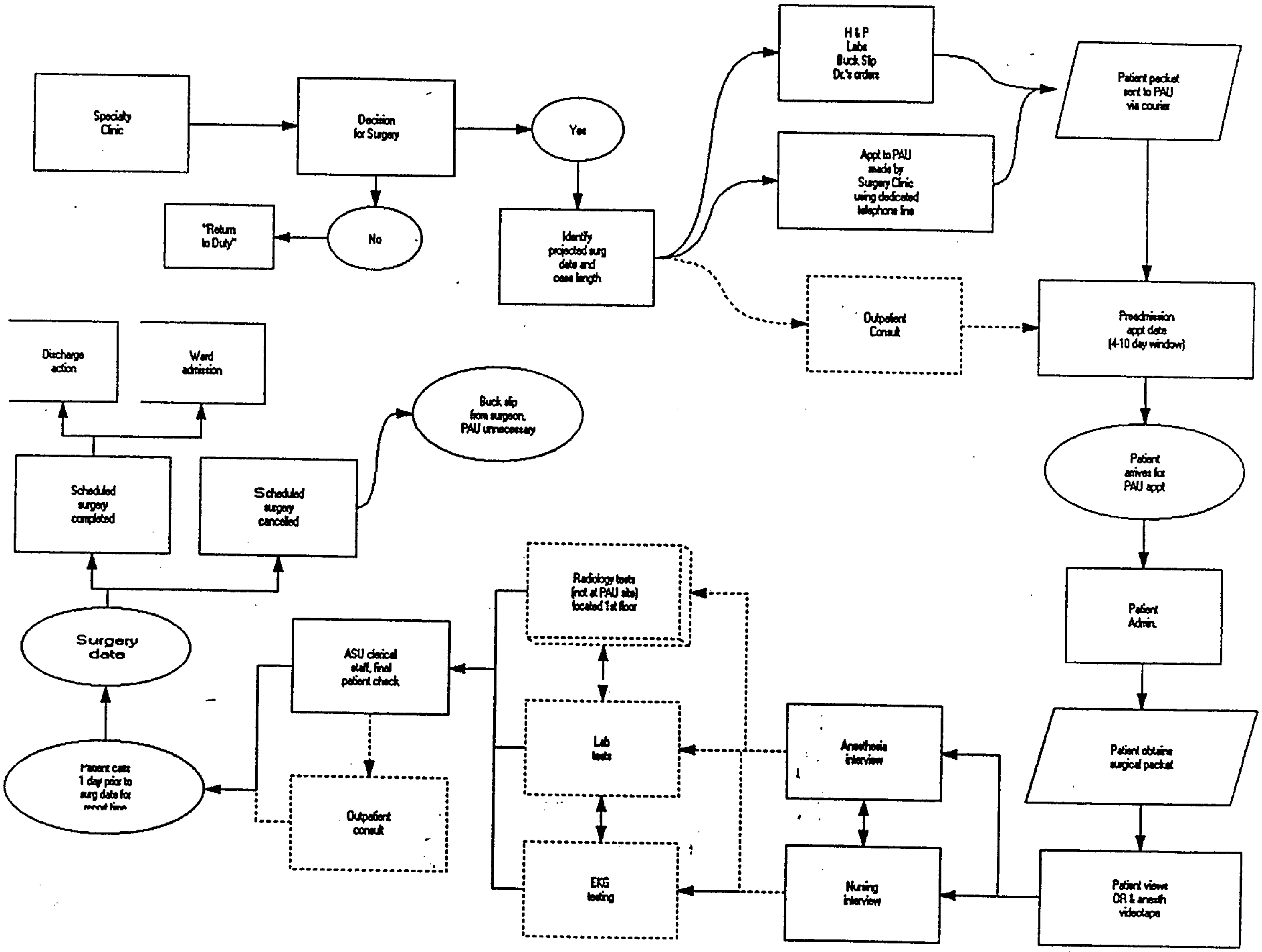
The purpose of this study was to collect and analyze data from two groups of patients to determine whether restructuring efforts were statistically significant, and provide the basis for simulating three computer models which act to replicate and predict outcomes for future managerial decisions. With the help of simulation software packages, we can effectively utilize computer modeling programs to quantitatively compare alternative processes in a risk-free environment (White, Best, and Sage 1992). The use of computer simulation in the analysis of processes enables managers to "what if" the model for improved operational efficiency. This management philosophy can potentially achieve significant cost-savings to the organization in the future (Schiess 1993).

The results of these efforts should be used as a model to improve other internal processes within Womack because it utilizes computer simulation to quantify process alternatives before they are implemented. This ultimately saves time and money for the organization, while maximizing the use of automation in an era of budget cuts and limited resources. Any time the solution to a problem is process oriented, quantitatively analyzed, and involves input from all specialties with a long term emphasis on continuous quality improvement for the patient, then the probability of its success is favorable.

APPENDIX 1
Status Quo Flow Chart



APPENDIX 2
Alternatives #1 and #2 Flow Charts



APPENDIX 3
Time Collection Sheet

Return to Nancy when finished
Main info desk, 1st floor

Control # ______

	IN	OUT
System	______	______
Anesthesia	______	______
Nursing	______	______
Admissions	______	______
Lab	______	______
Xray	______	______
EKG	______	______

Beginning 6 March 1995, the pre-admission process will be redesigned so that patients will not have to wait as long in the system. We intend to do this by scheduling appointments throughout the day, instead of at 1300 only. Please help us by recording the time you enter and leave each part of the process. For example, record the time you enter and leave the Anesthesiologist's office. Do not include the time you wait in line, because that time will be accounted for by our staff with the information you give us. We will collect the same data from patients after the new process is implemented to see if the changes we make are affective.

APPENDIX 4a
Status Quo Consolidated Time Collection Sheet

APPENDIX 4 — Consolidated Time Collection Sheet — Status Quo	SYSTEM			ANESTHESIA			NURSING			PAD			LAB			XRAY			EKG			Avg Wait Time
CONTROL #	In	Out	Proc. Time	In	Out	Proc. Time	In	Out	Proc. Time	In	Out	Proc. Time	In	Out	Proc. Time	In	Out	Proc. Time	In	Out	Proc. Time	(minutes)
1	1100	1410	190	1345	1405	20	1330	1340	10	1100	1120	20	1130	1140	10							130
2	1300	1530	150	1505	1510	5	1450	1455	5	1530	1540	10	1335	1345	10	1320	1330	10	1430	1440	10	100
3	1300	1715	255	1310	1330	20	1420	1430	10	1646	1715	29	1520	1533	13	1535	1640	65	1438	1515	37	81
4	1300	1505	125				1410	1425	15	1430	1500	30										80
5	1300	1521	141				1400	1415	15	1515	1521	6										120
6	1300	1523	143	1404	1409	5	1350	1401	11	1414	1450	36	1452	1520	28							63
7	1300	1545	165	1414	1429	15				1440	1545	65										85
8	1300	1515	135	1315	1325	10	1400	1402	2	1425	1510	45	1405	1425	20							58
9	1300	1530	150	1420	1435	15	1407	1415	8	1436	1528	52										75
10	1300	1429	89	1350	1355	5	1308	1315	7	1355	1428	33										44
11	1300	1511	131										1330	1340	10				1430	1500	30	91
12	1300	1330	30	1325	1330	5	1315	1320	5													20
13	1252	1330	38				1252	1313	21	1315	1330	15										2
14	1230	1355	85	1315	1340	25	1230	1250	20	1342	1355	13										27
15	1300	1348	48				1336	1345	10													38
16	1300	1402	62	1335	1347	12	1315	1334	19	1355	1402	7	1350	1355	5							19
17	1300	1410	70	1315	1321	6	1300	1310	10	1400	1410	10	1325	1355	30							14
18	1300	1410	70	1320	1330	10	1310	1315	5	1415	1435	20	1335	1410	35							0
19	1300	1540	160	1345	1350	5	1400	1410	10	1415	1530	75	1535	1540	5							65
20	1300	1600	180				1345	1407	22													158
21	1300	1600	180	1447	1455	8	1430	1445	15	1513	1600	47							1457	1510	13	97
22	1300	1645	225	1335	1415	40	1300	1330	30	1455	1610	75	1415	1450	35	1350	1410	20				25
23	1300	1645	225	1334	1355	21	1425	1436	10	1630	1645	15	1620	1625	5	1508	1615	67	1440	1505	25	82
24	1300	1625	205	1345	1355	10	1545	1550	5	1620	1623	3										187
25	1300	1510	130				1425	1435	10	1500	1510	10										110
Average Time			135			13			12			29			17			41			23	71
Standard Deviation			62			9			7			23			12			30			11	48
Avg # Requesting Interview/Testing						64%			92%			84%			52%			17%			22%	

APPENDIX 4b
Alternative #1, Consolidated Time Collection Sheet

APPENDIX 4 — Consolidated Time Collection Sheet — Alternative #1	SYSTEM			ANESTHESIA			NURSING			PAD			LAB			XRAY			EKG			Avg Wait Time
CONTROL #	In	Out	Proc. Time	In	Out	Proc. Time	In	Out	Proc. Time	In	Out	Proc. Time	In	Out	Proc. Time	In	Out	Proc. Time	In	Out	Proc. Time	(minutes)
1	1245	1450	125				1325	1337	12	1255	1303	8	1400	1410	10							95
2	1200	1340	100	1247	1258	11	1310	1338	28													61
3	1215	1325	70	1238	1245	7	1302	1310	8	1315	1325	10										45
4	1215	1350	95	1310	1320	10	1340	1350	10													75
5	1245	1422	97	1255	1300	5	1325	1335	10				1345	1422	37							45
6	1045	1105	20	1053	1100	7	1100	1105	5													8
7	1100	1140	40	1111	1119	8	1119	1140	21							1130	1140	10				1
8	940	1024	44	1001	1009	8	1012	1024	12	949	959	10										14
9	915	1012	57	920	926	6	1002	1012	10	928	957	29										12
10	915	1020	65	950	957	7				930	950	20	957	1020	23							15
11	945	1055	70	1030	1037	7	1010	1030	20	1000	1009	9	1037	1040	3							31
12	945	1102	77	1018	1025	7	1026	1035	9				1045	1054	9				1054	1102	8	44
13	1030	1100	30	1045	1057	12	1057	1100	3	1040	1045	5										10
14	1020	1125	65	1115	1120	5	1036	1050	14	1030	1035	5	1105	1115	10							31
15	900	1130	150	1048	1115	28	940	1030	50				1100	1130	30							42
16	900	1130	150				1000	1020	20				945	1000	15	1000	1130	90				25
17	1015	1143	88	1110	1118	8	1055	1110	15				1140	1143	3							62
18	1000	1125	85	1035	1040	5	1040	1055	15	1015	1025	10	1120	1123	3							52
19	845	1055	140	955	1009	14	945	950	5	1035	1055	20										101
20	830	955	85				905	928	23	950	955	5										57
21	815	940	85	847	907	20	915	935	20	842	847	5										40
22	800	930	90				840	900	20	920	930	10										60
23	800	905	65							850	905	15										50
24	800	920	80				915	920	5	910	915	5										70
25	1300	1342	42				1324	1340	16	1305	1310	5										21
26	1215	1330	75	1243	1254	11	1316	1326	10	1235	1242	7	1304	1314	10							37
27	1245	1338	53	1330	1338	8	1300	1314	14													31
28	1230	1333	63	1327	1330	3	1300	1327	27	1245	1250	5	1250	1300	10							18
29	1230	1322	52	1305	1319	14	1235	1248	13				1249	1304	15							10
30	1215	1320	65	1300	1310	10	1240	1250	10	1310	1320	10										35
31	1000	1222	142	1013	1033	20	1035	1054	19				1055	1120	25	1133	1222	49				29
Average Time			80			10			15			10			15			50			8	40
Standard Deviation			34			6			9			7			11			40			1	25
Avg # Requesting Interview/Testing						77%			94%			61%			45%			10%			3%	

APPENDIX 5
GPSS/H Output for Status Quo Simulation

```
STUDENT GPSS/H RELEASE 2.01 (EP292)     06 Jul 1995   16:06:18      FILE: PAU1.gps
LINE# STMT#  IF DO  BLOCK#  *LOC    OPERATION A,B,C,D,E,F,G          COMMENTS

  1    1                            SIMULATE
  2    2                      *
  3    3                            STORAGE       S(RNA),2/S(PAD),3/S(LAB),5/S(XRAY),2
  4    4                      *
  5    5                      *
  6    6                1           GENERATE      0,,,20
  7    7                2           QUEUE         SYSQ
  8    8                3           QUEUE         ADMINQ
  9    9                4           SEIZE         ADMIN
 10   10                5           ADVANCE       3,1
 11   11                6           RELEASE       ADMIN
 12   12                7           DEPART        ADMINQ
 13   13                8           TRANSFER      .30,,LPN
 14   14
 15   15                9           QUEUE         RNAQ
 16   16               10           ENTER         RNA
 17   17               11           ADVANCE       13,9
 18   18               12           LEAVE         RNA
 19   19               13           DEPART        RNAQ
 20   20
 21   21               14   LPN     QUEUE         LPNQ
 22   22               15           SEIZE         LPN
 23   23               16           ADVANCE       12,7
 24   24               17           RELEASE       LPN
 25   25               18           DEPART        LPNQ
 26   26               19           TRANSFER      .54,,PAD
 27   27
 28   28               20           QUEUE         LABQ
 29   29               21           ENTER         LAB
 30   30               22           ADVANCE       17,12
 31   31               23           LEAVE         LAB
 32   32               24           DEPART        LABQ
 33   33               25           TRANSFER      .80,,PAD
 34   34
 35   35               26           QUEUE         XRAYQ
 36   36               27           ENTER         XRAY
 37   37               28           ADVANCE       41,30
 38   38               29           LEAVE         XRAY
 39   39               30           DEPART        XRAYQ
 40   40
 41   41               31           QUEUE         EKGQ
 42   42               32           SEIZE         EKG
 43   43               33           ADVANCE       23,11
 44   44               34           RELEASE       EKG
 45   45               35           DEPART        EKGQ
 46   46
 47   47               36   PAD     QUEUE         PADQ
 48   48               37           ENTER         PAD
 49   49               38           ADVANCE       29,23
 50   50               39           LEAVE         PAD
 51   51               40           DEPART        PADQ
```

APPENDIX 5
GPSS/H Output for Status Quo Simulation Continued

```
52   52      41     DEPART      SYSQ
53   53      42     TERMINATE   1
54   54         *
55   55             START       20
56   56             CLEAR
57   57             START       20
58   58             CLEAR
59   59             START       20
60   60             END
```

Simulation begins.

FACILITY	--AVG-UTIL-DURING-- TOTAL TIME	AVAIL TIME	UNAVL TIME	ENTRIES	AVERAGE TIME/XACT	CURRENT STATUS	PERCENT AVAIL	SEIZING XACT	PREEMPTING XACT
ADMIN	0.179			20	2.885	AVAIL			
EKG	0.083			2	13.311	AVAIL			
LPN	0.749			20	12.058	AVAIL			

STORAGE	--AVG-UTIL-DURING-- TOTAL TIME	AVAIL TIME	UNAVL TIME	ENTRIES	AVERAGE TIME/UNIT	CURRENT STATUS	PERCENT AVAIL	CAPACITY	AVERAGE CONTENTS	CURRENT CONTENTS	MAXIMUM CONTENTS
RNA	0.266			13	13.154	AVAIL	100.0	2	0.531	0	2
LAB	0.187			14	21.504	AVAIL	100.0	5	0.935	0	4
XRAY	0.167			2	53.773	AVAIL	100.0	2	0.334	0	2
PAD	0.599			20	28.918	AVAIL	100.0	3	1.796	0	3

QUEUE	MAXIMUM CONTENTS	AVERAGE CONTENTS	TOTAL ENTRIES	ZERO ENTRIES	PERCENT ZEROS	AVERAGE TIME/UNIT	$AVERAGE TIME/UNIT	QTABLE NUMBER	CURRENT CONTENTS
SYSQ	20	11.254	20	0		181.156	181.156		0
ADMINQ	20	1.818	20	0		29.262	29.262		0
RNAQ	9	1.321	13	0		32.721	32.721		0
LPNQ	11	4.543	20	0		73.134	73.134		0
LABQ	4	0.935	14	0		21.504	21.504		0
XRAYQ	2	0.334	2	0		53.773	53.773		0
EKGQ	2	0.110	2	0		17.637	17.637		0
PADQ	6	2.193	20	0		35.298	35.298		0

RANDOM STREAM	ANTITHETIC VARIATES	INITIAL POSITION	CURRENT POSITION	SAMPLE COUNT	CHI-SQUARE UNIFORMITY
1	OFF	100000	100145	145	0.44

FACILITY	--AVG-UTIL-DURING-- TOTAL TIME	AVAIL TIME	UNAVL TIME	ENTRIES	AVERAGE TIME/XACT	CURRENT STATUS	PERCENT AVAIL	SEIZING XACT	PREEMPTING XACT
ADMIN	0.172			20	2.737	AVAIL			
EKG	0.152			2	24.134	AVAIL			
LPN	0.747			20	11.890	AVAIL			

APPENDIX 5
GPSS/H Output for Status Quo Simulation Continued

STORAGE	--AVG-UTIL-DURING-- TOTAL TIME	AVAIL TIME	UNAVL TIME	ENTRIES	AVERAGE TIME/UNIT	CURRENT STATUS	PERCENT AVAIL	CAPACITY	AVERAGE CONTENTS	CURRENT CONTENTS	MAXIMUM CONTENTS
RNA	0.195			11	11.302	AVAIL	100.0	2	0.391	0	2
LAB	0.101			9	17.892	AVAIL	100.0	5	0.506	0	3
XRAY	0.149			2	47.336	AVAIL	100.0	2	0.298	0	1
PAD	0.692			20	33.015	AVAIL	100.0	3	2.075	0	3

QUEUE	MAXIMUM CONTENTS	AVERAGE CONTENTS	TOTAL ENTRIES	ZERO ENTRIES	PERCENT ZEROS	AVERAGE TIME/UNIT	$AVERAGE TIME/UNIT	QTABLE NUMBER	CURRENT CONTENTS
SYSQ	20	11.857	20	0		188.657	188.657		0
ADMINQ	20	1.808	20	0		28.766	28.766		0
RNAQ	4	0.449	11	0		12.976	12.976		0
LPNQ	14	6.018	20	0		95.747	95.747		0
LABQ	3	0.506	9	0		17.892	17.892		0
XRAYQ	1	0.298	2	0		47.336	47.336		0
EKGQ	1	0.152	2	0		24.134	24.134		0
PADQ	7	2.628	20	0		41.810	41.810		0

RANDOM STREAM	ANTITHETIC VARIATES	INITIAL POSITION	CURRENT POSITION	SAMPLE COUNT	CHI-SQUARE UNIFORMITY
1	OFF	100145	100278	133	0.07

FACILITY	--AVG-UTIL-DURING-- TOTAL TIME	AVAIL TIME	UNAVL TIME	ENTRIES	AVERAGE TIME/XACT	CURRENT STATUS	PERCENT AVAIL	SEIZING XACT	PREEMPTING XACT
ADMIN	0.159			20	2.805	AVAIL			
EKG	0.234			3	27.483	AVAIL			
LPN	0.742			20	13.073	AVAIL			

STORAGE	--AVG-UTIL-DURING-- TOTAL TIME	AVAIL TIME	UNAVL TIME	ENTRIES	AVERAGE TIME/UNIT	CURRENT STATUS	PERCENT AVAIL	CAPACITY	AVERAGE CONTENTS	CURRENT CONTENTS	MAXIMUM CONTENTS
RNA	0.261			15	12.264	AVAIL	100.0	2	0.522	0	2
LAB	0.084			10	14.746	AVAIL	100.0	5	0.418	0	2
XRAY	0.202			3	47.374	AVAIL	100.0	2	0.403	0	2
PAD	0.584			20	30.869	AVAIL	100.0	3	1.751	0	3

1

QUEUE	MAXIMUM CONTENTS	AVERAGE CONTENTS	TOTAL ENTRIES	ZERO ENTRIES	PERCENT ZEROS	AVERAGE TIME/UNIT	$AVERAGE TIME/UNIT	QTABLE NUMBER	CURRENT CONTENTS
SYSQ	20	11.033	20	0		194.502	194.502		0
ADMINQ	20	1.706	20	0		30.075	30.075		0
RNAQ	11	1.545	15	0		36.319	36.319		0
LPNQ	13	4.691	20	0		82.703	82.703		0

APPENDIX 5
GPSS/H Output for Status Quo Simulation Continued

LABQ	2	0.418	10	0	14.746	14.746	0
XRAYQ	2	0.403	3	0	47.374	47.374	0
EKGQ	2	0.312	3	0	36.658	36.658	0
PADQ	6	1.957	20	0	34.507	34.507	0

RANDOM STREAM	ANTITHETIC VARIATES	INITIAL POSITION	CURRENT POSITION	SAMPLE COUNT	CHI-SQUARE UNIFORMITY
1	OFF	100278	100419	141	0.59

Simulation terminated. Absolute Clock: 352.5835

APPENDIX 6
GPSS/H Output for Alternative #1

```
STUDENT GPSS/H RELEASE 2.01 (EP292)     06 Jul 1995   16:10:55     FILE: PAU2.gps
LINE# STMT#  IF DO  BLOCK#  *LOC   OPERATION A,B,C,D,E,F,G        COMMENTS

                                   SIMULATE
                            *
                                   STORAGE      S(XRAY),2
                            *
                      1            GENERATE     15
                      2            QUEUE        SYSQ
                      3            QUEUE        PADQ
                      4            SEIZE        PAD
                      5            ADVANCE      10,7
                      6            RELEASE      PAD
                      7            DEPART       PADQ
                      8            TRANSFER     .30,,LPN

                      9            QUEUE        RNAQ
                     10            SEIZE        RNA
                     11            ADVANCE      10,6
                     12            RELEASE      RNA
                     13            DEPART       RNAQ

                     14     LPN    QUEUE        LPNQ
                     15            SEIZE        LPN
                     16            ADVANCE      15,9
                     17            RELEASE      LPN
                     18            DEPART       LPNQ
                     19            TRANSFER     .54,,ADMIN

                     20            QUEUE        LABQ
                     21            SEIZE        LAB
                     22            ADVANCE      15,11
                     23            RELEASE      LAB
                     24            DEPART       LABQ
                     25            TRANSFER     .95,,ADMIN

                     26            QUEUE        XRAYQ
                     27            ENTER        XRAY
                     28            ADVANCE      50,40
                     29            LEAVE        XRAY
                     30            DEPART       XRAYQ
                     31            TRANSFER     .80,,ADMIN

                     32            QUEUE        EKGQ
                     33            SEIZE        EKG
                     34            ADVANCE      8,1
                     35            RELEASE      EKG
                     36            DEPART       EKGQ

                     37     ADMIN  QUEUE        ADMINQ
                     38            SEIZE        ADMIN
                     39            ADVANCE      3,1
                     40            RELEASE      ADMIN
                     41            DEPART       ADMINQ
```

APPENDIX 6
GPSS/H Output for Alternative #1 Continued

```
52   52        42         DEPART       SYSQ
53   53        43         TERMINATE    1
54   54             *
55   55                    START        420
56   56                    START        420
```

Simulation begins.

FACILITY	—AVG-UTIL-DURING— TOTAL TIME	AVAIL TIME	UNAVL TIME	ENTRIES	AVERAGE TIME/XACT	CURRENT STATUS	PERCENT AVAIL	SEIZING XACT	PREEMPTING XACT
PAD	0.686			426	10.309	AVAIL			
RNA	0.461			295	10.005	AVAIL		426	
LAB	0.425			181	15.017	AVAIL		420	
EKG	0.004			3	8.740	AVAIL			
LPN	0.980			422	14.855	AVAIL		422	
ADMIN	0.198			420	3.019	AVAIL			

STORAGE	—AVG-UTIL-DURING— TOTAL TIME	AVAIL TIME	UNAVL TIME	ENTRIES	AVERAGE TIME/UNIT	CURRENT STATUS	PERCENT AVAIL	CAPACITY	AVERAGE CONTENTS	CURRENT CONTENTS	MAXIMUM CONTENTS
XRAY	0.062			15	53.324	AVAIL	100.0	2	0.125	0	1

QUEUE	MAXIMUM CONTENTS	AVERAGE CONTENTS	TOTAL ENTRIES	ZERO ENTRIES	PERCENT ZEROS	AVERAGE TIME/UNIT	$AVERAGE TIME/UNIT	QTABLE NUMBER	CURRENT CONTENTS
SYSQ	10	5.279	426	0		79.302	79.302		6
PADQ	2	0.697	426	0		10.475	10.475		0
RNAQ	2	0.489	295	0		10.615	10.615		1
LPNQ	8	3.276	425	0		49.331	49.331		4
LABQ	3	0.490	181	0		16.983	16.983		1
XRAYQ	1	0.125	15	0		53.324	53.324		0
EKGQ	1	0.004	3	0		8.740	8.740		0
ADMINQ	2	0.207	420	0		3.150	3.150		0

RANDOM STREAM	ANTITHETIC VARIATES	INITIAL POSITION	CURRENT POSITION	SAMPLE COUNT	CHI-SQUARE UNIFORMITY
1	OFF	100000	102804	2804	0.78

FACILITY	—AVG-UTIL-DURING— TOTAL TIME	AVAIL TIME	UNAVL TIME	ENTRIES	AVERAGE TIME/XACT	CURRENT STATUS	PERCENT AVAIL	SEIZING XACT	PREEMPTING XACT
PAD	0.670			854	10.059	AVAIL			
RNA	0.471			610	9.893	AVAIL		854	
LAB	0.432			378	14.650	AVAIL			
EKG	0.004			6	8.525	AVAIL			
LPN	0.990			841	15.094	AVAIL		841	
ADMIN	0.194			840	2.967	AVAIL			

APPENDIX 6
GPSS/H Output for Alternative #1 Continued

STORAGE	--AVG-UTIL-DURING-- TOTAL TIME	AVAIL TIME	UNAVL TIME	ENTRIES	AVERAGE TIME/UNIT	CURRENT STATUS	PERCENT AVAIL	CAPACITY	AVERAGE CONTENTS	CURRENT CONTENTS	MAXIMUM CONTENTS-
XRAY	0.067			30	56.936	AVAIL	100.0	2	0.133	0	1

QUEUE	MAXIMUM CONTENTS	AVERAGE CONTENTS	TOTAL ENTRIES	ZERO ENTRIES	PERCENT ZEROS	AVERAGE TIME/UNIT	$AVERAGE TIME/UNIT	QTABLE NUMBER	CURRENT CONTENTS
SYSQ	19	8.707	854	0		130.750	130.750		14
PADQ	2	0.680	854	0		10.214	10.214		0
RNAQ	2	0.499	610	0		10.498	10.498		1
LPNQ	17	6.698	853	0		100.706	100.706		13
LABQ	3	0.488	378	0		16.569	16.569		0
XRAYQ	1	0.133	30	0		56.936	56.936		0
EKGQ	1	0.004	6	0		8.525	8.525		0
ADMINQ	3	0.203	840	0		3.106	3.106		0

RANDOM STREAM	ANTITHETIC VARIATES	INITIAL POSITION	CURRENT POSITION	SAMPLE COUNT	CHI-SQUARE UNIFORMITY
1	OFF	100000	105661	5661	0.96

FACILITY	--AVG-UTIL-DURING-- TOTAL TIME	AVAIL TIME	UNAVL TIME	ENTRIES	AVERAGE TIME/XACT	CURRENT STATUS	PERCENT AVAIL	SEIZING XACT	PREEMPTING XACT
PAD	0.672			1273	10.087	AVAIL			
RNA	0.476			924	9.839	AVAIL		1273	
LAB	0.427			555	14.690	AVAIL		1259	
EKG	0.004			8	8.380	AVAIL			
LPN	0.993			1262	15.038	AVAIL		1262	
ADMIN	0.197			1260	2.989	AVAIL			

STORAGE	--AVG-UTIL-DURING-- TOTAL TIME	AVAIL TIME	UNAVL TIME	ENTRIES	AVERAGE TIME/UNIT	CURRENT STATUS	PERCENT AVAIL	CAPACITY	AVERAGE CONTENTS	CURRENT CONTENTS	MAXIMUM CONTENTS
XRAY	0.056			38	55.856	AVAIL	100.0	2	0.111	0	2

QUEUE	MAXIMUM CONTENTS	AVERAGE CONTENTS	TOTAL ENTRIES	ZERO ENTRIES	PERCENT ZEROS	AVERAGE TIME/UNIT	$AVERAGE TIME/UNIT	QTABLE NUMBER	CURRENT CONTENTS
SYSQ	21	10.721	1273	0		160.928	160.928		13
PADQ	2	0.683	1273	0		10.251	10.251		0
RNAQ	2	0.506	924	0		10.472	10.472		1
LPNQ	18	8.722	1272	0		131.022	131.022		11
LABQ	3	0.489	555	0		16.852	16.852		1
XRAYQ	2	0.111	38	0		55.856	55.856		0
EKGQ	1	0.004	8	0		8.380	8.380		0
ADMINQ	3	0.206	1260	0		3.122	3.122		0

APPENDIX 6
GPSS/H Output for Alternative #1 Continued

RANDOM STREAM	ANTITHETIC VARIATES	INITIAL POSITION	CURRENT POSITION	SAMPLE COUNT	CHI-SQUARE UNIFORMITY
1	OFF	100000	108446	8446	1.00

Simulation terminated. Absolute Clock: 19108.4216

APPENDIX 7
GPSS/H Output for Alternative #2

STUDENT GPSS/H RELEASE 2.01 (EP292) 06 Jul 1995 16:11:20 FILE: PAU3.gps

LINE#	STMT#	IF DO	BLOCK#	*LOC	OPERATION	A,B,C,D,E,F,G	COMMENTS
1	1				SIMULATE		
2	2			*			
3	3		1		GENERATE	15	
4	4		2		QUEUE	SYSQ	
5	5		3		QUEUE	PADQ	
6	6		4		SEIZE	PAD	
7	7		5		ADVANCE	10,5	
8	8		6		RELEASE	PAD	
9	9		7		DEPART	PADQ	
10	10		8		TRANSFER	.30,,LPN	
11	11						
12	12		9		QUEUE	RNAQ	
13	13		10		SEIZE	RNA	
14	14		11		ADVANCE	15	
15	15		12		RELEASE	RNA	
16	16		13		DEPART	RNAQ	
17	17						
18	18		14	LPN	QUEUE	LPNQ	
19	19		15		SEIZE	LPN	
20	20		16		ADVANCE	15	
21	21		17		RELEASE	LPN	
22	22		18		DEPART	LPNQ	
23	23		19		TRANSFER	.54,,ADMIN	
24	24						
25	25		20		QUEUE	LABQ	
26	26		21		SEIZE	LAB	
27	27		22		ADVANCE	10,5	
28	28		23		RELEASE	LAB	
29	29		24		DEPART	LABQ	
30	30		25		TRANSFER	.95,,ADMIN	
31	31						
32	32		26		QUEUE	XRAYQ	
33	33		27		SEIZE	XRAY	
34	34		28		ADVANCE	20,10	
35	35		29		RELEASE	XRAY	
36	36		30		DEPART	XRAYQ	
37	37		31		TRANSFER	.80,,ADMIN	
38	38						
39	39		32		QUEUE	EKGQ	
40	40		33		SEIZE	EKG	
41	41		34		ADVANCE	10,5	
42	42		35		RELEASE	EKG	
43	43		36		DEPART	EKGQ	
44	44						
45	45		37	ADMIN	QUEUE	ADMINQ	
46	46		38		SEIZE	ADMIN	
47	47		39		ADVANCE	3,1	
48	48		40		RELEASE	ADMIN	
49	49		41		DEPART	ADMINQ	
50	50		42		DEPART	SYSQ	
51	51		43		TERMINATE	1	

APPENDIX 7
GPSS/H Output for Alternative #2 Continued

```
52   52
53   53          START      420
54   54          START      420
55   55          START      420
56   56          END
```

Simulation begins.

FACILITY	—AVG-UTIL-DURING— TOTAL TIME	AVAIL TIME	UNAVL TIME	ENTRIES	AVERAGE TIME/XACT	CURRENT STATUS	PERCENT AVAIL	SEIZING XACT	PREEMPTING XACT
PAD	0.675			424	10.124	AVAIL		424	
RNA	0.736			312	15.000	AVAIL			
LAB	0.321			210	9.714	AVAIL			
XRAY	0.017			6	17.675	AVAIL		421	
EKG	0.001			1	7.041	AVAIL			
LPN	0.993			422	14.971	AVAIL		422	
ADMIN	0.198			420	2.993	AVAIL			

QUEUE	MAXIMUM CONTENTS	AVERAGE CONTENTS	TOTAL ENTRIES	ZERO ENTRIES	PERCENT ZEROS	AVERAGE TIME/UNIT	$AVERAGE TIME/UNIT	QTABLE NUMBER	CURRENT CONTENTS
SYSQ	6	3.516	424	0		52.767	52.767		4
PADQ	1	0.675	424	0		10.124	10.124		1
RNAQ	2	0.858	312	0		17.501	17.501		0
LPNQ	3	1.440	423	0		21.658	21.658		2
LABQ	1	0.321	210	0		9.714	9.714		0
XRAYQ	1	0.017	6	0		17.675	17.675		1
EKGQ	1	0.001	1	0		7.041	7.041		0
ADMINQ	2	0.205	420	0		3.110	3.110		0

RANDOM STREAM	ANTITHETIC VARIATES	INITIAL POSITION	CURRENT POSITION	SAMPLE COUNT	CHI-SQUARE UNIFORMITY
1	OFF	100000	102120	2120	0.49

FACILITY	—AVG-UTIL-DURING— TOTAL TIME	AVAIL TIME	UNAVL TIME	ENTRIES	AVERAGE TIME/XACT	CURRENT STATUS	PERCENT AVAIL	SEIZING XACT	PREEMPTING XACT
PAD	0.669			844	10.029	AVAIL		844	
RNA	0.707			597	14.991	AVAIL		843	
LAB	0.313			405	9.787	AVAIL		842	
XRAY	0.022			14	19.940	AVAIL			
EKG	0.002			2	10.537	AVAIL			
LPN	0.996			842	14.984	AVAIL		841	
ADMIN	0.199			840	2.993	AVAIL			

QUEUE	MAXIMUM CONTENTS	AVERAGE CONTENTS	TOTAL ENTRIES	ZERO ENTRIES	PERCENT ZEROS	AVERAGE TIME/UNIT	$AVERAGE TIME/UNIT	QTABLE NUMBER	CURRENT CONTENTS

APPENDIX 7
GPSS/H Output for Alternative #2 Continued

SYSQ	6	3.530	844	0		52.961	52.961		4
PADQ	1	0.669	844	0		10.029	10.029		1
RNAQ	2	0.806	597	0		17.092	17.092		1
LPNQ	3	1.511	842	0		22.727	22.727		1
LABQ	1	0.313	405	0		9.787	9.787		1
XRAYQ	1	0.022	14	0		19.940	19.940		0
EKGQ	1	0.002	2	0		10.537	10.537		0
ADMINQ	2	0.208	840	0		3.132	3.132		0

RANDOM STREAM	ANTITHETIC VARIATES	INITIAL POSITION	CURRENT POSITION	SAMPLE COUNT	CHI-SQUARE UNIFORMITY
1	OFF	100000	104207	4207	0.84

FACILITY	--AVG-UTIL-DURING-- TOTAL TIME	AVAIL TIME	UNAVL TIME	ENTRIES	AVERAGE TIME/XACT	CURRENT STATUS	PERCENT AVAIL	SEIZING XACT	PREEMPTING XACT
PAD	0.668			1263	10.015	AVAIL		1263	
RNA	0.711			899	14.994	AVAIL		1262	
LAB	0.308			592	9.858	AVAIL			
XRAY	0.023			23	19.201	AVAIL			
EKG	0.002			3	11.570	AVAIL			
LPN	0.998			1261	14.990	AVAIL		1260	
ADMIN	0.198			1260	2.981	AVAIL			

QUEUE	MAXIMUM CONTENTS	AVERAGE CONTENTS	TOTAL ENTRIES	ZERO ENTRIES	PERCENT ZEROS	AVERAGE TIME/UNIT	$AVERAGE TIME/UNIT	QTABLE NUMBER	CURRENT CONTENTS
SYSQ	6	3.530	1263	0		52.960	52.960		3
PADQ	1	0.668	1263	0		10.015	10.015		1
RNAQ	2	0.805	899	0		16.969	16.969		1
LPNQ	3	1.518	1261	0		22.802	22.802		1
LABQ	1	0.308	592	0		9.858	9.858		0
XRAYQ	1	0.023	23	0		19.201	19.201		0
EKGQ	1	0.002	3	0		11.570	11.570		0
ADMINQ	2	0.207	1260	0		3.110	3.110		0

RANDOM STREAM	ANTITHETIC VARIATES	INITIAL POSITION	CURRENT POSITION	SAMPLE COUNT	CHI-SQUARE UNIFORMITY
1	OFF	100000	106278	6278	0.98

Simulation terminated. Absolute Clock: 18947.3288

APPENDIX 8
A Consolidation of GPSS/H Results

Average Time Per Unit, a.k.a. Average Processing Time
(In minutes)

	Status Quo	Alternative #1	Alternative #2
Replication 1	181	79	53
Replication 2	188	130	53
Replication 3	194	160	53
Mean	188	123	53
Std Deviation	7	41	0

Maximum Contents in the Queue
(Figures are an average of 3 replications)

	Status Quo	Alternative #1	Alternative #2
Administration	20	3	2
RNA	8	2	2
LPN	13	14	3
Lab	3	3	1
X-ray	2	1	1
EKG	2	1	1
PAD	6	2	1
System	20	17	6

Average Contents in the Queue
(Figures are an average of 3 replications)

	Status Quo	Alternative #1	Alternative #2
Administration	1.80	0.21	0.21
RNA	1.10	0.50	0.83
LPN	5.10	6.20	1.50
Lab	0.62	0.49	0.31
X-ray	0.34	0.12	0.02
EKG	0.19	0.00	0.00
PAD	2.30	0.69	0.67
System	11.00	8.00	3.50

Utilization Rate of Providers
(Figures are an average of 3 replications)

	Status Quo	Alternative #1	Alternative #2
Administration	17%	20%	20%
RNA	24%	50%	70%
LPN	75%	99%	100%
Lab	12%	43%	31%
X-ray	17%	6%	2%
EKG	15%	0%	0%
PAD	63%	68%	67%

APPENDIX 9
Statistical Analyses

t-Test: Paired Two-Sample for Means		
	Status Quo	*Alternative #1*
Mean	135.23	79.52
Variance	3039.68	1143.99
Observations	31.00	31.00
Pearson Correlation	-0.08	
df	30.00	
t	4.64	
t Critical one-tail (95% CI, p<.0005)	1.70	

Anova: Between 3 Computer Simulated Sample Means

Summary

Groups	*Count*	*Sum*	*Average*	*Variance*
Status Quo	3	563	187.667	42.3333
Alternative #1	3	369	123	1677
Alternative #2	3	159	53	0

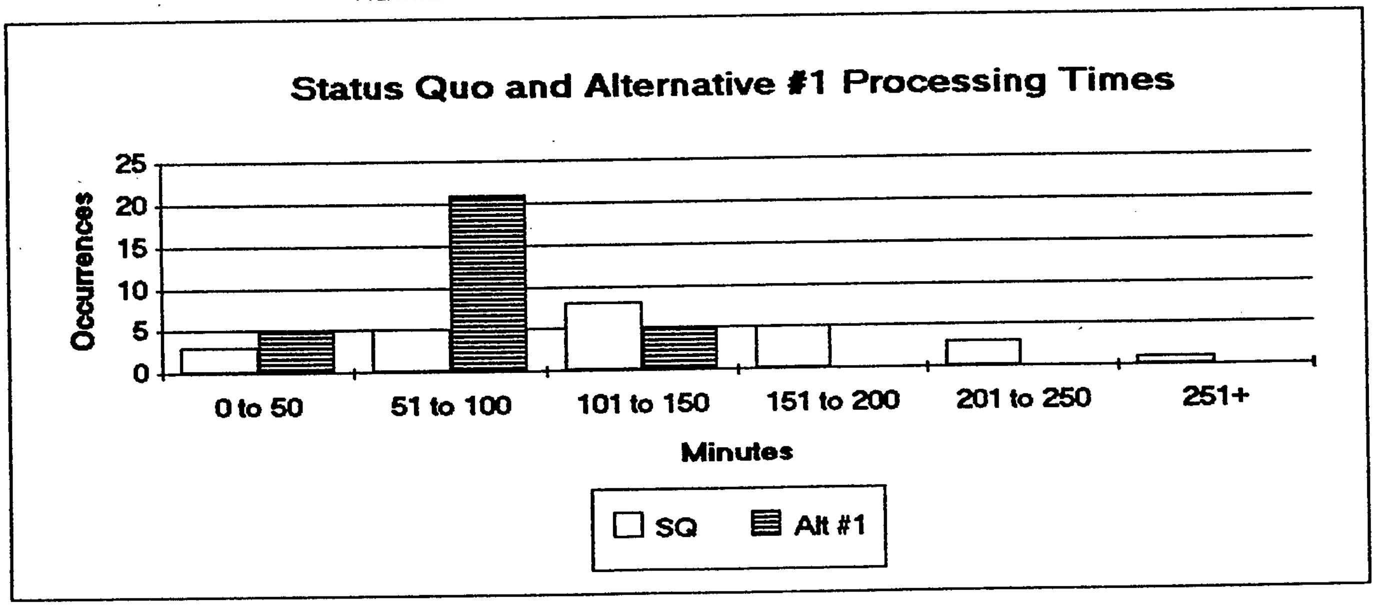
ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	27216.88889	2	13608.4	23.7449	0.001411376	5.143249382
Within Groups	3438.666667	6	573.111			
Total	30655.55556	8				

APPENDIX 10
Descriptive Statistics, Histogram

Descriptive Statistics
Pre-admission Processing

	Status Quo	Alternative #1
Mean	135	80
Std Error	12	6
Median	141	75
SD	62	34
Variance	3799	1144
Range	225	130
Minimum	30	20
Maximum	255	150



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